FORM PTO-1390 (Modified) U.S. DEPARTM[illegible]RCE PATENT AND TRADEMARK OFFICE
(REV 11-98)

ATTORNEY'S DOCKET NUMBER
**WEI0027**

# TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
**09/936916**

| INTERNATIONAL APPLICATION NO. | INTERNATIONAL FILING DATE | PRIORITY DATE CLAIMED |
|---|---|---|
| **PCT/EP00/02507** | **22 March 2000 (22/03/2000)** | **23 March 1999 (23/03/1999)** |

TITLE OF INVENTION
**METHOD AND DEVICE FOR THE HOMOGENOUS HEATING OF GLASS AND/OR GLASS-CERAMIC ARTICLES USING INFRARED RADIATION**

APPLICANT(S) FOR DO/EO/US
**Ulrich Fotheringham et al.**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

**Items 13 to 20 below concern document(s) or information included:**

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☒ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

**Check No.** 100859

| U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR) | INTERNATIONAL APPLICATION NO. | ATTORNEY'S DOCKET NUMBER |
|---|---|---|
| 09/936916 | PCT/EP00/02507 | WE10027 |

21. The following fees are submitted:.

| BASIC NATIONAL FEE ( 37 CFR 1.492 (a) (1) - (5)) : | | CALCULATIONS PTO USE ONLY |
|---|---|---|
| ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... | $1,000.00 | |
| ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO ..... | $860.00 | |
| ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... | $710.00 | |
| ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... | $690.00 | |
| ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ..... | $100.00 | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | | $860.00 |
| Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)). | | $0.00 |

| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | |
|---|---|---|---|---|
| Total claims | 34 - 20 = | 14 | x $18.00 | $252.00 |
| Independent claims | 2 - 3 = | 0 | x $80.00 | $0.00 |
| Multiple Dependent Claims (**check if applicable**). | | | ☐ | $0.00 |
| **TOTAL OF ABOVE CALCULATIONS** | | | = | $1,112.00 |
| Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (**check if applicable**). | | | ☐ | $0.00 |
| **SUBTOTAL** | | | = | $1,112.00 |
| Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). | | | + | $0.00 |
| **TOTAL NATIONAL FEE** | | | = | $1,112.00 |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (**check if applicable**). | | | ☐ | $0.00 |
| **TOTAL FEES ENCLOSED** | | | = | $1,112.00 |
| | | | Amount to be: refunded | $ |
| | | | charged | $ |

☒ A check in the amount of **$1,112.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. in the amount of to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **02-0385** A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

**JOHN F. HOFFMAN**
NAME

**26,280**
REGISTRATION NUMBER

**September 20, 2001**
DATE

I, Peter Nelles, do hereby certify that I am an experienced translator, knowledgeable in both the English and German languages, that I have made the attached translation from German to English of the Patent Application entitled "Method and Device for the Homogeneous Heating of Glass and/or Glass-Ceramic Articles Using Infrared Radiation", and that, to the best of my knowledge and belief, it is a true and complete rendering into English of the original document in German.

Date: Aug. 31, 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
|---|---|---|
| In re Application of | ) | |
| Ulrich Fotheringham et al. | ) | Group: |
| Serial No. | ) | |
| Filed: | ) | Examiner: |
| Title: METHOD AND DEVICE FOR THE HOMOGENOUS HEATING OF GLASS AND/OR GLASS-CERAMIC ARTICLES USING INFRARED RADIATION | ) | |

**PRELIMINARY AMENDMENT DELETING MULTIPLE DEPENDENT CLAIMS**

Assistant Commissioner of Patents
Washington, DC 20231

Sir:

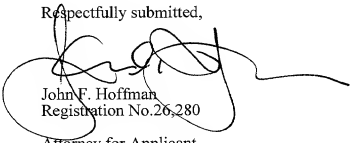
Prior to calculating the filing fee, please enter the following amendments to the application.

**IN THE CLAIMS**

In claim 3, line 1, delete "one of claims 1 or 2" and substitute therefor --claim 1--.
In claim 4, line 1, delete "one of claims 1 to 3" and substitute therefor --claim 1--.
In claim 5, line 1, delete "one of claims 1 to 4" and substitute therefor --claim 1--.
In claim 9, line 1, delete "one of claims 8 to 8" and substitute therefor --claim 1--.
In claim 11, line 1, delete "10".
In claim 12, line 1, delete "one of claims 9 to 11" and substitute therefor --claim 9--.
In claim 13, line 1, delete "one of claims 9 to 12" and substitute therefor --claim 9--.
In claim 14, line 1, delete "one of claims 9 to 13" and substitute therefor --claim 9--.
In claim 17, line 1, delete "one of claims 15 to 16" and substitute therefor --claim 15--.
In claim 21, line 1, delete "one of claims 16 to 20" and substitute therefor --claim 16--.
In claim 22, line 1, delete "one of claims 15 to 21" and substitute therefor --claim 15--.
In claim 24, line 1, delete "one of claims 22 to 25" and substitute therefor --claim 22--.
In claim 25, line 1, delete "one of claims 22 to 24" and substitute therefor --claim 22--.
In claim 26, line 1, delete "one of claims 22 to 25" and substitute therefor --claim 22-.
In claim 27, line 1, delete "one of claims 15 to 26" and substitute therefor --claim 15--.
In claim 28, line 1, delete "one of claims 15 to 26" and substitute therefor --claim 15--.
In claim 29, line 1, delete "one of claims 15 to 26" and substitute therefor --claim 15--.
In claim 30, line 1, delete "one of claims 15 to 26" and substitute therefor --claim 15--.

In claim 31, line 1, delete "one of claims 15 to 26" and substitute therefor --claim 15--.
In claim 32, line 1, delete "one of claims 15 to 26" and substitute therefor --claim 15--.
In claim 33, line 1, delete "one of claims 15 to 26" and substitute therefor --claim 15--.
In claim 34, line 1, delete "one of claims 15 to 26" and substitute therefor --claim 15--.

Respectfully submitted,



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Date: September 20, 2001

3/pdx

WO 00/56675
PCT/EP00/02507

**(0001)** Method and device for the homogeneous heating of glass and/or glass-ceramic articles using infrared radiation

**(0002)** The invention relates to a process for the homogeneous heating of semi-transparent and/or transparent glass articles and/or of glass-ceramic articles with the aid of infrared radiation, whereby the glass articles and/or the glass-ceramic articles undergo a heat treatment in the range from 20°C to 3000°C, as well as to a device for the homogeneous heating of translucent and/or transparent glass articles and/or glass-ceramic.

**(0003)** Semi-transparent or transparent glass and/or glass- ceramics, for the setting-in of certain material properties, for example ceramization, are heated mostly to temperatures which lie preferably over the lower cooling point (viscosity $\eta = 10^{14.5}$ dPas). In form-giving processes, especially hot after-processing (Heissnachverarbeitung), the semi-transparent or transparent glass and/or the glass-ceramic material is heated up to the processing point (viscosity $\eta = 10^{4}$ dPas) or beyond that. Typical lower cooling points can amount, depending on the type of glass, to between 282°C and 790°C, and typically the processing point can be up to 1705°C.

**(0004)** Hitherto according to the state of the art semi-transparent or transparent glasses and/or glass-ceramics, for example for ceramization, were heated preferably with surface heating. As surface heating there are designated processes in which at least 50% of the total heat output of the heat source is introduced into the surface or surface-near layers of the object to be heated.

**(0005)** If the radiation source is black or gray and if it has a color temperature of 1500 K, then the source radiates off 51% of the total radiation output in a wavelength range above 2.7 µm. If the color temperature is less than 1500 K, as in most electric resistance heating elements, then

substantially more than 51% of the radiation output is given off above 2.7 µm.

**(0006)** Since most glasses in this wavelength range have an absorption edge (Absorptionskante), 50% or more of the radiation output is absorbed by the surface or in surface-near layers. It is possible, therefore, to speak of surface heating. Another possibility lies in heating glass and glass-ceramics with a gas flame, in which typical flame temperatures lie at 1000°C. Such a heating occurs mainly by direct transfer of the thermal energy of the hot gas onto the surface of the glass or of the glass-ceramic, so that here it is possible to proceed from a predominantly surface / superficial / heating.

**(0007)** In general with the earlier described surface heating the surface or surface-near layers are heated in the parts of the glass or of the glass-ceramic that lie opposite the heating source. The remaining glass volume or glass-ceramic volume must accordingly be heated up correspondingly by heat conduction within the glass or the glass-ceramic material.

**(0008)** Since glass or glass-ceramic material has as a rule a very low heat conductivity in the range of 1 W (m K), glass or glass-ceramic material must be heated up more and more slowly in order to keep tensions in the glass or glass-ceramics low.

**(0009)** A further disadvantage of known systems is that, in order to achieve a homogeneous heating-up of the surface, the surface of the glass or of the glass-ceramic material must be covered as completely as possible with heating elements. Limits are placed there on conventional heating processes. With electrical heating resistances made of Kanthal wire (Kanthaldrähen), as they are preferably used, at 1000°C, for example, only a wall load of maximally 60 kW/m² is possible, while a full-surfaced (or holohedral) black radiator of the

same temperature could irradiate an output density of 149 $kW/m^2$.

**(0010)** With a denser packing of the heating elements to be equated with a higher wall load, these would heat themselves up reciprocally, which through the resulting heat accumulation (Wärmestau) would involve an extreme shortening of the useful life of the heating elements.

**(0011)** When a homogeneous heating-up of the glass or of the glass-ceramic is not achieved or is only inadequately successful, then this unfailingly results in inhomogeneities in the process and/or in the product quality. For example, any irregularity in the process conducting, in the ceramization process of glass-ceramics leads to a cambering (Durchbiegen) or bursting of the glass-ceramic article.

**(0012)** From DE 42 02 944 C2 there has become known a process and a device comprising IR radiators for the rapid heating of materials which have a high absorption above 2500 nm. In order to rapidly introduce, into the material, the heat given off from the IR radiators, DE 42 02 944 C2 proposes the use of a radiation converter from which secondary radiation is emitted with a wavelength range which is shifted into the long-wave direction with respect to the primary radiation.

**(0013)** A heating of transparent glass homogeneous in depth with use of short-wave IR radiators is described in US-A-3620706. The process according to US-A-3620706 is based on the principle that the absorption length of the radiation used in glass is very much greater than the dimensions of the glass object to be heated, so that the major part of the impinging radiation is lest through by the glass and the absorbed energy per volume is nearly equal at every point of the glass body. What is disadvantageous in this process, however, is that no homogeneous irradiation over the surface of the glass objects is ensured, so that the intensity distribution of the IR radiation source is depicted on the glass to be heated.

Moreover, in this process only a small part of the electric energy used is utilized for the heating of the glass.

**(0014)** The problem of the invention, therefore, is to give a process and a device for the homogeneous heating-up of semi-transparent or transparent glass and glass-ceramic articles, with which the aforementioned disadvantages are overcome.

**(0015)** According to the invention the problem is solved by the means that in a generic process the heating of the semi-transparent and/or transparent glass or glass-ceramic material is achieved by a component of infrared radiation acting directly on the glass and/or glass-ceramic material as well as a component of infrared radiation acting indirectly on the glass and/or glass-ceramic material,the share of the radiation acting indirectly on the glass or the glass-ceramic material being more than 50%, preferably more than 60%, preferably more than 70%, especially preferably more than 80%, especially preferably more than 90%, in particular more than 98% of the total radiation output.

**(0016)** It is preferred if the infrared radiation is short-wave infrared radiation with a color temperature greater than 1500 K, especially preferably greater than 2000 K, most preferably greater than 2400 K, especially greater than 2700 K, especially preferably greater than 3000 K.

**(0017)** In a first form of execution of the invention it is provided that the infrared radiation acting indirectly on the glass and/or glass-ceramic material comprises at least a component of reflected and/or scattered, especially diffusely scattered, radiation. Advantageously the component of the short-wave infrared radiation that is not absorbed by the glass or glass-ceramic material in the one-time impinging, i.e., reflected, scattered or let through, is on the average

more than 50% of the total radiation output given off by the IR radiators.

**(0018)** If, for example, it is desired to cool slowly or heat rapidly, then in an advantageous execution of the invention it is provided that the process is carried out in an enclosed space, preferably an IR radiation hollow space. In an especially advantageous execution of such a process it is provided that the reflected and/or scattered infrared radiation is reflected and/or scattered by at least a part of the wall, base and/or cover surfaces. IR radiation hollow spaces are shown for example in US-A-4789771 as well as EP-A-0 133 847, the disclosure content of which is fully taken into account in the present application. Preferably the component of the infrared radiation reflected and/or scattered from the part of the wall, base and/or cover surfaces amounts to more than 50% of the radiation impinging on these surfaces.

**(0019)** It is especially preferred if the component of the infrared radiation reflected and/or scattered from the part of the wall, base and/or cover surfaces amounts to more than 90%, respectively 95%, in particular more than 98%.

**(0020)** A special advantage of using an IR radiation hollow space is, further, that with use of very strongly reflecting or back-scattering wall, base and/or cover materials it is a matter of a resonator of high Q quality, which is affected with only slight losses and, therefore, ensures a high utilization of energy.

**(0021)** In an alternative development of the invention it is provided that the infrared radiation acting indirectly on the glass and/or glass-ceramic materials comprises a component of infrared radiation which is absorbed by a carrier body, transformed into heat and is given off onto the glass and/or the glass-ceramic material thermally bound with the carrier body.

**(0022)** In a first development of this alternative it is provided that as carrier body ceramic plates are used.

**(0023)** It is especially advantageous if with the carrier body it is a matter of a highly heat-conductive carrier body of as high as possible emissivity, preferably of SiSiC in the form of plates.

**(0024)** Especially advantageously the heat conductivity of the carrier body in the range of the heat treatment temperature is at least five times as great as that of the glass and/or of the glass-ceramic material to be treated.

**(0025)** Besides the method, the invention also makes available a device for carrying out the method. The device of the invention is characterized in that means are provided for the generating of an infrared radiation acting indirectly on the glass and/or glass-ceramic materials, which means are arranged and designed in such manner that the component of the radiation acting indirectly on the glass and/or the glass-ceramic material amounts to more than 50% of the total radiation output.

**(0026)** In a first development of the invention it is provided that the means for generating an infrared radiation acting indirectly on the glass and/or glass-ceramic materials comprise reflectors and/or diffusors for the reflection and scattering, respectively, of the infrared radiation.

**(0027)** As diffusely back-scattering material there are used, for example, ground quarzal plates with a thickness of 30 mm. for example.

**(0028)** Also other materials reflecting or back-scattering the IR radiation are possible, for example one or more of the following materials:

$Al_2O_3$; $BaF_2$; $BaTiO_3$; $CaF_2$; $CaTiO_3$; MgO; 3.5 $Al_2O_3$; MgO, $SrF_2$; $SiO_2$; $SrTiO_3$; $TiO_2$; spinell; cordierite; cordierite sinter glass-ceramic

**(0029)** If a rapid heating or a slow cooling is sought, then it is advantageously provided to accommodate the device in a bounded space, especially an IR radiation hollow space.

**(0030)** In a special development of the invention it is provided that the surface of the walls, of the bases and/or of the cover of the bounded space, preferably of the IR radiation hollow space, comprises the reflectors or diffusors.

**(0031)** One form of execution of the diffusor, for example, would be a diffusing screen.

**(0032)** It is especially preferred if the reflectors or diffusors are designed in such manner that more than 50% of the radiation impinging on these surfaces is reflected or scattered, respectively.

**(0033)** In an alternative form of execution it is provided that the means for the generation of indirect radiation comprise a carrier body which stands in thermal contact with the glass and/or glass-ceramic materials and absorbs a share of the indirect infrared radiation.

**(0034)** It is especially preferred if the carrier body comprises ceramic plates, preferably of SiSiC, and the emissivity of the carrier body is greater than 0.5. SiSiC has a high heat conductivity as well as a low porosity as well as a low adhesive tendency with respect to glass. The low porosity has the consequence that only a few undesired particles can collect in the pores. For this reason SiSiC is especially well suited for working in direct contact with glass.

**(0035)** In an especially advantageous form of execution it is provided that the heat conductivity of the carrier body, in the range of the heat treatment temperature, is at least five times as great as that of the glass or of the glass-ceramic material to be treated.

**(0036)** The invention is to be described in the following by way of example with the aid of the figures as well as of the examples of execution.

**(0037)** In the drawings:

Fig. 1 shows the transmission course with a thickness of 1 cm of a typical glass material to be heated;

Fig. 2 the Planck curve of the IR radiator used with a temperature of 2400 K

Fig. 3A the theoretical construction of a heating device with radiation hollow space.

Fig. 3B the remission curve over the wavelength of $Al_2O_3$ Sintox Al of the Morgan Matroc, Troisdorf, with a remission degree > 95% in the near-IR wavelength range;

Fig. 4 the heating curve of a glass material in a heating device comprising diffusors and reflectors;

Fig. 5 the heating curve of a glass material in a device with an absorbent carrier body.

**(0038)** Fig. 1 shows the transmission curve over the wavelength of glass material used for the comparative tests of the present invention. The glass material has a thickness of 10 mm. There is clearly to be recognized the typical absorption edge at 2.7 µm, over which the glass or glass-ceramic material is opaque, so that the entire impinging radiation is absorbed on the surface or in the surface-near layers.

**(0039)** Fig. 2 shows the intensity distribution of the preferably used IR radiation source. The IR radiators used are linear halogen IR quartz tube radiators with a nominal output of 2000 W at a voltage of 230 V, which have a color temperature of 2400 K. The IR radiators, corresponding to Wiensch's displacement law, have their radiation maximum at a wavelength of 1210 nm.

**(0040)** The intensity distribution of the IR radiation sources is yielded correspondingly from the Planck function of a black body with a temperature of 2400 K. It follows then that an appreciable intensity, i.e. an intensity greater than 5% of the radiation maximum, is released in the wavelength range of 500 to 5000 nm, and altogether ca. 75% of the total radiation output falls in the wavelength range above 1210 nm.

**(0041)** In a first form of execution of the invention only the annealing material (Glühgut) is heated, while the environment remains cold.

**(0042)** The radiation passing by the annealing material is led by reflectors or diffusing scatterers or diffusing backscatterers (Rückstreuer) onto the annealing material. In the case of high output densities and preferably of metal reflectors, the reflectors are water-cooled, since otherwise the reflector material would tarnish. This hazard is present especially with aluminum, which, because of its good reflecting properties in the IR range, is gladly used for radiators, especially for those of great radiation output. Alternatively to metal reflectors there can be used diffusely backscattering ceramic diffusors or partially reflecting and partially backscattering glazed reflectors, especially $Al_2O_2$.

**(0043)** A construction in which only the annealing material is heated can be used only when, after the heating-up, no slow cooling is required which, without insulating

space, is obtainable with an acceptable homogeneity of temperature only with continuous reheating and only with a very high expenditure.

**(0044)** The advantage of such a construction is, however, the easy accessibility of the annealing material, for example for grippers (Greifer) which is of great interest especially in hot shaping (Heissformgebung).

**(0045)** In an alternative form of execution the heating device and the annealing material are located in an IR radiation hollow space equipped with IR radiators. This presumes that the quartz radiators themselves are sufficiently temperature stable or are cooled. The quartz glass tube is usable up to about 1100°C. It is preferred to make the quartz glass tube considerably longer than the heating spiral and to lead it out of the heating zone, so that the connections are in the cold zone in order not to overheat the electrical connections. The quartz glass tubes can be constructed with and without coating.

**(0046)** In Fig. 3A a form of execution of a heating device according to the invention is represented with which the execution of the process of the invention is possible, without the invention being restricted to this.

**(0047)** The heating device shown in Fig. 3A comprises a large number of IR radiators 1 which are arranged underneath a reflector 3 made of strongly reflecting or diffusely backscattering material. By the reflector 3 it is achieved that the glass or glass-ceramic material 5 to be heated is heated from the upper side. The IR radiation given off from the IR radiators penetrates the glass or the glass-ceramic material 5 largely transparent in this wavelength range, and it impinges upon a carrier plate 7 of strongly reflecting or strongly scattering material. Especially well suited for this is quartz, which also in the infrared range backscatters

approximately 90% of the impinging radiation. Alternatively to this there could also be used highly pure, sintered $Al_2O_3$, which has a backscattering, i.e. remission degree of approximately 98% with adequate thickness. The glass or glass-ceramic material 5 is emplaced on the carrier plate 7 with the aid of, for example, quarzal or $Al_2O_3$ strips 9. The temperature of the glass or glass-ceramic material underside can be measured through a hole 11 in the carrier plate with the aid of a pyrometer (not represented).

**(0048)** The walls 10, together with reflector 3 as cover and carrier plate 7 as base, with corresponding formation with reflecting material, for example quarzal or $Al_2O_3$ can form an IR radiation hollow space of high quality.

**(0049)** Fig. 4 shows the heating curve of a borosilicate glass according to a process of the invention, in which the glass sample had dimensions of about 1100 mm with a thickness of 3 mm.

**(0050)** The heating process or the heat treatment took place as described in the following:

The heating of the glass samples occurred first of all in an IR radiation hollow space walled-in with quarzal according to Fig. 3A, the cover of which was formed by an aluminum reflector with IR radiators present under it. The glass samples or glass-ceramic bodies were borne in a suitable manner on quarzal.

**(0051)** In the IR radiation hollow space the glass or the glass-ceramic material was irradiated directly by several halogen IR radiators, which were located at a distance of 10 mm to 150 mm over the glass or the glass-ceramic material.

**(0052)** The heating-up of the glass or of the glass-ceramic material now took place by means of orientation (Ansteuerung) of the IR radiators over a thyristor plate on the basis of absorption, reflection and scattering processes, as thoroughly described in the following:

**(0053)** Since the absorption length of the used short wave IR radiation in the glass or in the glass-ceramic material is very much greater than the dimensions of the objects to be heated, the major part of the impinging radiation is allowed to pass through the sample. Since, on the other hand, the absorbed energy per volume at very point of the glass or glass-ceramic body is nearly equal, there is achieved a homogeneous heating over the entire volume. In the process according to Fig. 4 the IR radiators and the glass material to be heated are located in a hollow space, the walls and/or cover and/or base of which consist of a material with a surface of high reflectivity or high backscattering capacity, in which at least a part of the wall, base, and/or cover surface scatters back the impinging radiation predominantly diffusely. Thereby the predominant part of the radiation is let through again into the object to be heated and is again partially absorbed. The path of the radiation lest through the glass or the glass-ceramic material also in the second passage is analogously continued. With this process thee is achieved not only a heating homogenous in depth, but also the energy expended is clearly better utilized than in the case of only a single passage through the glass or the glass-ceramic material. It is especially preferred for the process described here that at least a part of the wall, base and/or cover surface does not reflect the impinging radiation directedly (gerichtret), but is diffusely backscattered. Thereby the radiation passes from all directions and under all possible angles into the glass or the glass-ceramic material, so that the heating simultaneously occurs homogeneously over the surface and a depiction of the intensity distribution of the radiation source onto the objects to be heated as hitherto in the state of the art.

**(0054)** Fig. 5 shows the heating curve of the glass according to an alternative process according to the invention

with absorbent carrier body. The diameter of the glass body was 100 mm with a thickness of 10 mm.

**(0055)** The heating occurred as described in the following:

First the glass sample outside of the radiation hollow space is emplaced on a carrier body of SiSiC with the thickness of 5 mm.

**(0056)** Thereupon the carrier made of SiSiC is introduced into a radiation hollow space surrounded with quarzal.

**(0057)** Thereupon the glass or the glass-ceramic material is directly irradiated with one or, according to the geometry of the glass of or the glass-ceramic material, also with several halogen IR radiators which are present in a reflector over the glass or the glass-ceramic material at a distance of 10 mm to 150 mm.

**(0058)** The heating-up of the glass or of the glass-ceramic material now takes place by the orientation of the IR radiators over a thyristor controller (Thyristorsteller) by a combination of direct and indirect heating.

**(0059)** Due to the transparency of the glass or of the glass-ceramic material a considerable share of the radiation output will radiate directly onto the carrier. The black SiSiC carrier absorbs nearly the entire radiation and distributes it rapidly and homogeneously over the entire surface of the carrier. The heat of the carrier is now given off likewise homogeneously to the glass or the glass-ceramic material and heats this from the underside. This process represents in the present process the indirect component of the heating-up.

**(0060)** The direct contribution to the heating-up is subdivided into two components. The first component is yielded from the fact that at all wavelengths outside of the transparent zone the glass or the glass-ceramic material is opaque and therewith the radiation can heat only the surface

or surface-near layers. The second contribution to the direct heating-up is delivered by the slightly absorbed part of the radiation, the wavelength of which lies in a range in which the glass or the glass-ceramic material absorbs weakly. This component leads to a heating-up of deeper layers of the glass or of the glass-ceramic material.

**(0061)** The major part of the IR radiation, however, penetrates the glass by radiation and results in an indirect heating-up over the carrier. Also in this process a high temperature homogeneity is achieved over the glass surface and in this manner there is avoided a depicting of the radiation source onto the glass as in the state of the art.

**(0062)** According to the invention the indirect component of the heating-up of the glass or of the glass-ceramic material in both the processes described in Figs. 4 and 5 amounts to more than 50%.

**(0063)** With the invention there are given for the first time processes and devices for the heating or supporting or exclusive heating of glass or of glass-ceramic materials which ensure a homogeneous heating of the same, have a high energy utilization as well as avoiding a depicting of the radiation source on the object to be heated. The process and the device can be used in a large number of areas of glass processing. Only by way of example and not exclusively so, let there be listed the following applications of the process of the invention:

- the temperature-homogeneous heating-up of glass-ceramic blanks in ceramization
- the rapid reheating of glass blanks for a following hot shaping
- the homogeneous heating of fiber bundles to drawing temperature
- the supporting and exclusive heating in mixture fusing
- the melting and purifying of glass and/or of glass-ceramic materials

- the supporting or exclusive heating in the shaping, especially in the drawing, in the rolling, in the casting, in the throwing (Schleudern), in the pressing, in the blowing in the blow-blow process, in the blowing in the press-blow process,in the blowing in the ribbon process, for the flat-glass production as well as in the floating
- the supporting or exclusive heating in the cooling, in the melting, in the thermal solidifying, in the stabilizing or fine cooling for the setting-in of a desired fictitious temperature, of a desired index of refraction, of a desired compaction with subsequent temperature treatment, in the aging of thermometer glasses, in the demixing, in the dyeing of tarnished glasses, in controlled crystallizing, in diffusion treatment, especially chemical solidifying, in reshaping, especially lowering, bending, buckling (Verziehen), blowing, in the separating, especially in the melting-off, breaking, setting (Schränken), bursting, in the cutting, in the joining as well as in coating.

Patent Claims

1. Process for the homogeneous heating of semi-transparent and/or transparent glass articles and/or glass-ceramic materials with the aid of infrared radiation, whereby the glass articles and/or glass-ceramic materials are subjected to a heat treatment in the range from 20°C to 1705°C. characterized in that the heating is achieved by a component of infrared radiation acting directly on the glass articles and or the glass-ceramic materials as well as a component of infrared radiation acting indirectly on the glass articles and/or glass-ceramic materials, in which the component of the radiation acting indirectly on the glass and/or the glass-ceramic materials amounts to more than 50% of the total radiation output.
2. Process according to claim 1, characterized in that the infrared radiation is a shortwave infrared radiation with a color temperature higher than 1500 K, especially preferably higher than 2000 K, quite preferably higher than 2400 K, especially higher than 2700 K, especially preferably higher than 3000 K.
3. Process according to one of claims 1 or 2, characterized in that the infrared radiation acting indirectly on the glass articles and/or the glass-ceramic material comprises a share of reflected and/or scattered radiation.
4. Process according to one of claims 1 to 3, characterized in that on the average more than 50% of the total radiation output of shortwave infrared radiation given off by the IR radiators is not absorbed in the once-through (einmaligen) impinging on the glass.
5. Process according to one of claims 1 to 4, characterized in that the process is carried out in a circumscribed

space with walls, base and cover, especially an IR radiation hollow space.

6. Process according to claim 5, characterized in that the reflected and/or scattered infrared radiation is reflected and/or scattered by at least a part of the wall, base and/or cover surfaces.
7. Process according to claim 6, characterized in that the component of the infrared radiation reflected and/or scattered from the part of the wall, base and/or cover surfaces amounts to more than 50% of the radiation striking these surfaces.
8. Process according to claim 6, characterized in that the share of the infrared radiation reflected and/or scattered from the part of the wall, base and/or cover surfaces amounts to more than 90% or 95%, especially more than 98%.
9. Process according to one of claims 8 to 8, characterized in that the infrared radiation acting indirectly on the glass articles and/or glass-ceramic material comprises a component of infrared radiation that is absorbed by a carrier body, converted into heat and given off to the glass and/or glass-ceramic material thermally joined with the carrier body.
10. Process according to claim 9, characterized in that the heat is transferred to the glass thermally joined with the carrier body over heat radiation and/or heat conduction and/or convection.
11. Process according to claim 9 or 10, characterized in that as carrier body ceramic plates are used.
12. Process according to one of claims 9 to 11, characterized in that the carrier bodies comprise SiC, especially SiSiC.

13. Process according to one of claims 9 to 12, characterized in that the emissivity of the carrier body is higher than 0.5.

14. Process according to one of claims 9 to 13, characterized in that the heat conductivity of the carrier body in the range of the heat treatment temperature is at least five times as high as that of the glass or of the glass-ceramic material to be treated.

15. Device for the homogeneous heating of semi-transparent and/or transparent glass and/or glass-ceramic material, especially in the range from $20^0$C to $3000^0$, especially in the range from $20^0$C to $1705^0$C with

15.1 infrared radiation sources (1) for the emission of shortwave infrared radiation;

15.2 means for the generation of infrared radiation acting indirectly on the glass and/or glass-ceramic material. characterized in that

15.3 the means for the generation of infrared radiation acting indirectly on the glass articles and/or glass-ceramic material are arranged and designed in such manner that the component of the radiation acting indirectly on the glass or the glass-ceramic material amounts to more than 50% of the total radiation output.

16. Device according to claim 15, characterized in that the means for the generation of infrared radiation acting indirectly on the glass articles and/or glass-ceramic material (5) comprise reflectors (3) or diffusors for the reflection or scattering of infrared radiation.

17. Device according to one of claims 15 to 16, characterized in that the device comprises a space encircled with walls, base and cover, in particular an IR radiation hollow space.

18. Device according to claim 17, characterized in that the surface of the walls and/or of the base and/or of the

cover of the encircled space comprises the reflectors or diffusors.

19. Device according to claim 18, characterized in that the reflectors or diffusors are designed in such manner that more than 50% of the radiation impinging on these surfaces is reflected or scattered.

20. Device according to claim 19, characterized in that the reflectors or diffusors are designed in such manner that more than 90%, or 95%, respectively, especially more than 98% of the radiation impinging on these surfaces is reflected or scattered.

21. Device according to one of claims 16 to 20, characterized in that the reflectors (3) or diffusors (3) comprise one of, or mixtures of, several of the following materials:
$Al_2O_3$; $BaF_2$; $BaTiO_3$; $CaF_2$; $CaTiO_3$;
MgO; 3.5 $Al_2O_3$; MgO, $SrF_2$; $SiO_2$;
$SrTiO_3$; $TiO_2$; quarzal; spinell,
Cordierite; cordierite sinter glass-ceramic

22. Device according to one of claims 15 to 21, characterized in that the means for the generation of radiation acting indirectly on the glass and/or the glass-ceramic material comprise a carrier body that stands in thermal contact with the glass articles or glass-ceramic material and absorbs a component of the indirect infrared radiation.

23. Device according to claim 22, characterized in that the carrier body comprises ceramic plates.

24. Device according to claim 22 or 23, characterized in that the carrier body comprises SiC, especially SiSiC.

25. Device according to one of claims 22 to 24, characterized in that the emissivity of the carrier body is greater than 0.5.

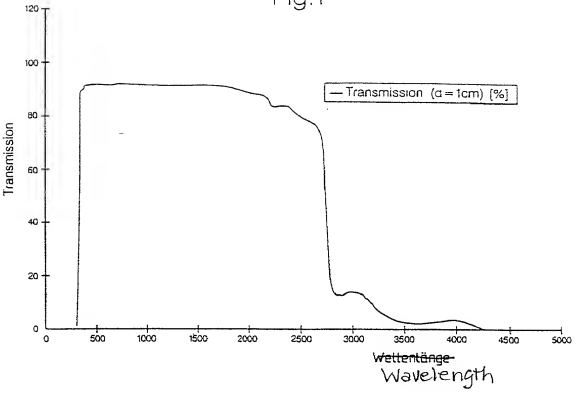
26. Device according to one of claims 22 to 25, characterized in that the heat conductivity of the carrier body in the range of the heat treatment temperature is at least five

times as high as that of the glass or of the glass-ceramic material to be treated.

27. Usage of a device according to one of claims 15 to 26 for the rapid, temperature-homogeneous heating-up of glass-ceramic blanks in the ceramization.
28. Usage of a device according to one of claims 15 to 26 for the rapid reheating of glass blanks for a subsequent hot shaping.
29. Usage of a device according to one of claims 15 to 26 for the countersinking (Absenken) of glass articles and/or glass-ceramic material.
30. Usage of a device according to one of claims 15 to 26 as a fiber-drawing furnace (Faserziehofen) for the homogeneous heating of fiber bundles to drawing temperature.
31. Usage of a device according to one of claims 15 to 26 for the supporting and exclusive heating in the mixture meltdown (Gemengeeinschmelzung).
32. Usage of a device according to one of claims 15 to 26 for the purifying melting of glass articles and/or glass-ceramic material.
33. Usage of a device according to one of claims 15 to 26 for the supportive or exclusive heating in the shaping, especially in the drawing, in the rolling, in the casting, in the throwing, in the pressing, in the blowing in the blow-blow process, in the blowing in the press-blow process, in the blowing in the ribbon process (Ribbon-Verfahren), for flat glass production as well as in the floating.
34. Usage of a device according to one of claims 15 to 26, for the supportive or exclusive heating in the cooling, in the melting, in the thermal solidification, in the stabilizing or fine cooling for the setting-in of a desired fictitious temperatures, of a desired index of

refraction, of a desired compaction with subsequent temperature treatment, in the aging of thermometer glasses, in the demixing (Entmischen), in the dyeing of tarnished glass, in the controlled crystallizing, in the diffusion treatment, in particular chemical solidifying, in the reshaping, in particular countersinking, bending, drawing, blowing, in the separating, especially melting-off, breaking, setting (Schränken), bursting, in the cutting, in the joining as well as in the coating.

Fig.1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— Transmission (α = 1cm) [%]
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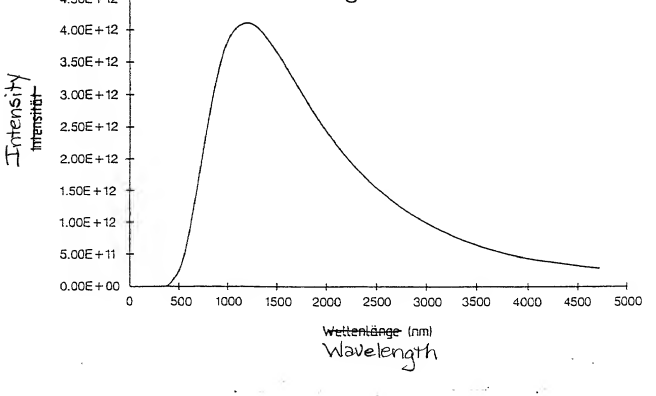
60
80
100
120
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Wellenlänge
Wavelength

Fig.2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Intensität
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1.00E+12
5.00E+11
0.00E+00
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1500
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3000
3500
4000
4500
5000
Wellenlänge (nm)
Wavelength

Fig.3A

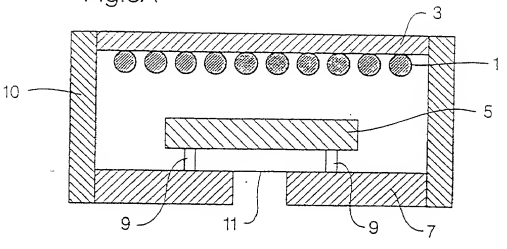



Fig.4

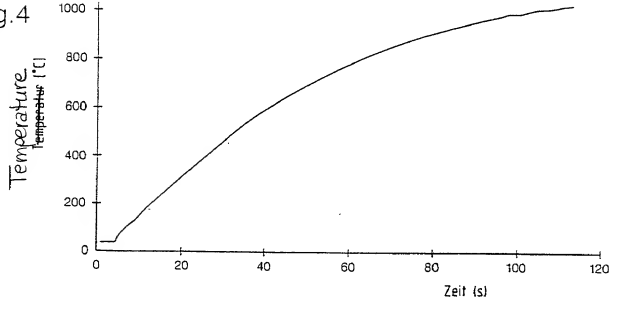
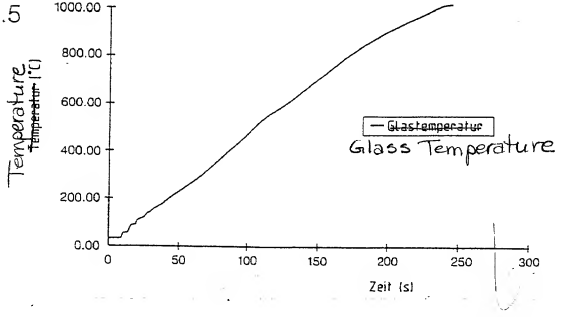
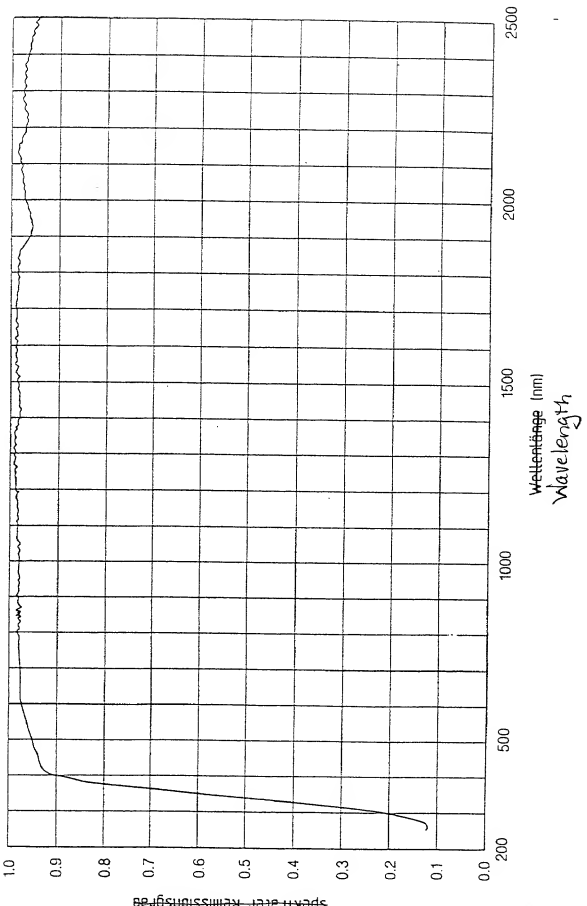



Fig.5




Spektral Diffuse Reflektanz
spektraler Remissionsgrad
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
200
500
1000
1500
2000
2500
Wellenlänge [nm]
Wavelength

Fig.3B

P 14749US

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# Erklärung für Patentanmeldungen mit Vollmacht

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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD AND DEVICE FOR THE HOMOGENEOUS HEATING OF GLASS AND/OR GLASS-CERAMIC ARTICLES USING INRARED RADIATION

deren Beschreibung hier beigefügt ist, es sei denn (in diesem Falle Zutreffendes bitte ankreuzen), diese Erfindung

the specification of which is attached hereto unless the following box is checked:

☐ wurde angemeldet am _____ unter der US-Anmeldenummer oder unter der Internationalen Anmeldenummer im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT) _____ und am _____ abgeändert (falls zutreffend).

☒ was filed on March 22, 2000 as United States Application Number or PCT International Application Number PCT/EP00/02507 and was amended on _____ (if applicable).

Ich bestätige hiermit, daß ich den Inhalt der oben angegebenen Patentanmeldung, einschließlich der Ansprüche, die eventuell durch einen oben erwähnten Zusatzantrag abgeändert wurde, durchgesehen und verstanden habe.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Titel 37, Code of Federal Regulations, § 1.56 von Belang sind.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

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I hereby claim foreign priority under Title 35, United States Code, §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Applications<br>(Frühere ausländische Anmeldungen) | | | Priority Not Claimed<br>Priorität nicht beansprucht |
|---|---|---|---|
| 299 05 385.7<br>(Number)<br>(Nummer) | Germany<br>(Country)<br>(Land) | 23 March 1999<br>(Day/Month/Year Filed)<br>(Tag/Monat/Jahr der Anmeldung) | ☐ |
| 199 38 808.3<br>(Number)<br>(Nummer) | Germany<br>(Country)<br>(Land) | 19 August 1999<br>(Day/Month/Year Filed)<br>(Tag/Monat/Jahr der Anmeldung) | ☐ |

Ich beanspruche hiermit Prioritätsvorteile unter Title 35, US-Code, § 119(e) aller US-Hilfsanmeldungen wie unten aufgezählt.

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| (Application No.)<br>(Aktenzeichen) | (Filing Date)<br>(Anmeldetag) |
|---|---|
| (Application No.)<br>(Aktenzeichen) | (Filing Date)<br>(Anmeldetag) |

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| EP00/02507<br>(Application No.)<br>(Aktenzeichen) | 22 March 2000<br>(Filing Date)<br>(Anmeldetag) | Published<br>(Status) (patented, pending, abandoned)<br>(Status) (patentiert, schwebend, aufgegeben) |
|---|---|---|
| (Application No.)<br>(Aktenzeichen) | (Filing Date)<br>(Anmeldetag) | (Status) (patented, pending, abandoned)<br>(Status) (patentiert, schwebend, aufgegeben) |

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: *(list name and registration number)*

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| Unterschrift des zweiten Erfinders Datum | Second Inventor's signature Date<br>11/06/01 |
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(Supply similar information and signature for third and subsequent joint inventors.)

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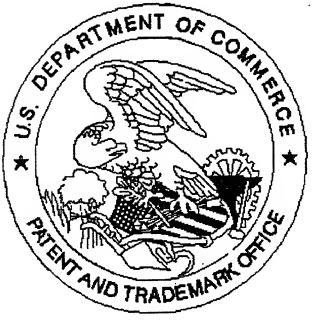


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